A room-temperature all-solid-state 4.7 THz multiplied LO source to enable the heterodyne observation of interstellar neutral oxygen

Completed Technology Project (2012 - 2016)

Project Introduction

Star formation is governed by gravity and heat. Triggered by a series of events, gravity's pull overcomes the random gas motions within a dense interstellar cloud, initiating a contraction phase that will last approximately 100,000 years and culminate in the formation of a star. During this collapse, the gas density increases. Collisions between atoms and molecules become more frequent and the gas temperature rises. Because the extent of the collapse is immense the resulting gas temperature increases from about 15 degrees Kelvin to over 11 million degrees Kelvin. Since a heated gas wants to expand, the cloud collapse could be halted or even reversed unless heat is effectively and continuously removed from the cloud. This cooling is mostly provided by emission of light of a variety of atoms and molecules, such as carbon, atom and molecular oxygen, carbon monoxide, hydroxyl and water. The tracers of most of these processes, which lie mostly in the submillimeter and infrared spectrum, had been observed with the Infrared Space Observatory (ISO), NASA's Kuiper Airborne Observatory (KAO), and are now accessible at unprecedented high spectral (R=Î»/Î”Î»>>1E6) and spatial resolution with the Heterodyne Instrument for the Far Infrared (HIFI) on-board the Herschel Space Observatory. A long standing problem for our understanding of the quiescent dense interstellar medium (ISM), often described as molecular clouds, is the difficulty of accounting for the gas-phase abundance of carbon and oxygen. Atomic oxygen OI (observable at 63 Âµm) together with CII (158 Âµm) are the major coolants of photo-dissociation regions (PDR) in giant molecular clouds, with OI emission usually dominant at densities typical of dense molecular clouds (n>1E4 cm-3). However, while CII and other coolants can be observed with high-resolution with Herschel/HIFI, the atomic oxygen has never been observed with resolutions better than ~ 7 km/s. Without high-resolution observations of the OI fine line in both emission and absorption, the models that 'predict' the chemistry of ISM cannot be verified, revised and/or completed. Until this problem is solved, or in other words, until the fine OI atomic line is observed in high spectral and spatial resolution, the chemistry of oxygen in interstellar clouds and protostellar regions, essential for understanding the formation of stars and the incorporation of key molecules into forming planetary system, will not be fully understood. As a response to this problem, we will develop the first all-solid-state continuous coherent local oscillator (LO) source at 4.7 THz to enable very high-resolution heterodyne observation (R=Î»/Î”Î» > 1E6) of the 4.748 THz (63.1837 Âµm) fine structure line of neutral atomic oxygen (OI). This source will be broadband, frequency-agile, temperature and frequency stable and will operate at room-temperature (no need of cryogenic cooling). With hot electron bolometer detectors (HEB) already available, the proposed source is the only technological part that is still missing to provide the radio-astronomers with this highly necessary science data for the complete understanding of star and planetary systems formation processes.

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Astrophysics Research and Analysis

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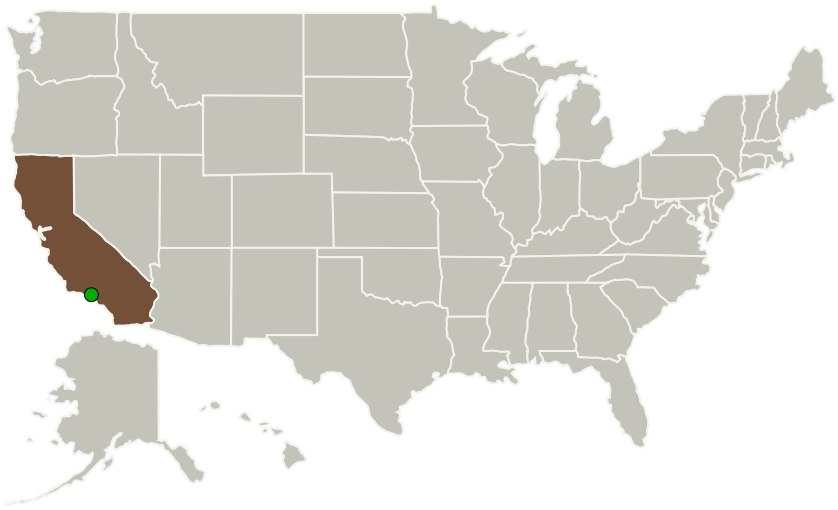
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations
California

Project Management

Program Director:

Michael A Garcia

Program Manager:

Dominic J Benford

Principal Investigator:

Jose V Siles Perez

Co-Investigators:

Cecile Jung-kubiak
Jorge L Pineda Galvez
Choon Sup Lee
Goutam Chattopadhyay
Imran Mehdi

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.4 Microwave, Millimeter-, and Submillimeter-Waves

Target Destination

Outside the Solar System